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# A FACTOR-ANALYTIC STUDY ACROSS THE DOMAINS OF REASONING, CREATIVITY, AND EVALUATION[1]

NORMAN W. KETTNER,[2] J. P. GUILFORD, AND PAUL R. CHRISTENSEN[3]

*University of Southern California*

THIS REPORT pertains to the sixth major study in a series of investigations designed to explore abilities considered to be important in the successful performance of high-level personnel. Previous studies had been concentrated on the areas of reasoning (Green, Guilford, Christensen, & Comrey, 1953; Guilford, Christensen, Kettner, Green, & Hertzka, 1954), creative thinking (Wilson, Guilford, Christensen, & Lewis, 1954), and evaluation (Hertzka, Guilford, Christensen, & Berger, 1954). The study reported here was designed to consolidate and extend the findings of earlier studies, the three main objectives being: (*a*) verification of factors, some of which had been found only once previously; (*b*) clarification of the nature of certain factors; and (*c*) derivation of information leading to improvement of tests measuring the factors.

### *General Plan of the Study*

The following major steps were involved in this study, in keeping with others undertaken in the project:

1. Formulation of specific hypotheses concerning the factors involved in the area of thinking investigated and concerning their properties. Only testable hypotheses were seriously entertained.
2. Selection, revision, and construction of tests that were believed to be suitable for testing the hypotheses.
3. Administration of the tests to personnel homogeneous as to sex and relatively homogeneous as to age, education, and general intellectual level.
4. Factor analysis of the intercorrelations among the tests.
5. Revision of original hypotheses, where needed, and formulations of new ones.

### *Selection of Factors to be Investigated*

In the previous studies in the domains of reasoning, creativity, and evaluation, 31 factors had been found. Eleven of these were reference factors, which have not been regarded as belonging within these domains. Of the remaining 20 factors, 11 were chosen for further investigation in this study. The selection was determined by several considerations. The foremost reason for inclusion was the need for further information, particularly where prospects of obtaining new information seemed promising. Some factors were omitted because they were too weak in previous studies to be identified. Others were omitted because it was planned to investigate them more intensively in other studies than would have been possible in this one.

The factors selected from the previous reasoning studies were *eduction of perceptual relations, eduction of conceptual relations, eduction of conceptual patterns, eduction of correlates,* and *symbol manipulation.* Factors from the creativity study were *sensitivity to problems, associational fluency, orginality,* and *redefinition.* Factors from the evaluation study were *facility with verbal relations* and *verbal classification.*

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[1] Under Contract N6onr-23810 with the Office of Naval Research. The ideas expressed in this paper are our own and do not necessarily represent the opinions of the Office of Naval Research. Reproduction in whole or in part is permitted for any purpose of the United States Government. Of the authors of this paper, J. P. Guilford is responsible investigator and director of the project, Paul R. Christensen was assistant director, and Norman W. Kettner was in direct charge of this particular study. For more detailed information see Guilford, Kettner, and Christensen (1954, 1956).

[2] Now with Planning Research Corporation.

[3] Now with System Development Corporation.

In addition, the following reference factors were included: *general reasoning, ideational fluency, logical evaluation, verbal comprehension, numerical facility,* and *judgment.*

## HYPOTHESES

### Testing Hypotheses by Factor Analysis

Six of the 11 factors selected for investigation had appeared in only one previous study in this series. These factors needed to be verified; they are: *eduction of conceptual patterns, associational fluency, originality, sensitivity to problems, facility with verbal relations,* and *verbal classification.* For each of these factors, in other words, the hypothesis that the factor exists was being tested. This was done by putting in the battery tests that were loaded on the factor in a previous study together with new and presumably improved tests designed for the factor, then seeing whether the factor would emerge again.

Other hypotheses concerned the nature of each factor. For 8 of the 11 factors alternative hypotheses were formulated. For most of the alternative hypotheses at least two tests each were constructed with the expectations that they would help to make decisions between alternatives where that is possible. If the tests that were aimed at one alternative hypothesis have substantial loadings on a factor and the tests aimed at a second hypothesis do not, we may define the factor as having the properties of the first hypothesis. If tests of two or more alternative hypotheses are all substantially loaded on a factor, the definition would need to include all the properties implied. In some instances, two alternative hypotheses may actually represent two different common factors, in which case two factors would probably replace the one formerly recognized.

It will be seen in what follows that in one or two instances the same alternative hypothesis is stated pertaining to two different factors. In this case there is suspicion that the two factors, previously found in different analyses, may be one and the same. In such cases we were testing whether two such factors are, in fact, probably identical.

### Some General Background of the Hypotheses

In general, alternative hypotheses were based upon consideration of results of previous studies. One alternative hypothesis for each factor was based upon the latest definition of that factor. Others might be other previously tested hypotheses that could not be rejected, or previously stated hypotheses not heretofore adequately tested. Still others represent new thinking regarding factors.

Some of the hypotheses pertain to the degree of generality of factors. In our first and only acquaintance with the factor of *sensitivity to problems,* for example, the ability seemed to be much more restricted in scope than had been originally expected. The factor had been expected to apply to the sensing of almost anything in the environment that is unusual, awry, challenging, or bothersome. As things turned out, it did not reflect anything beyond appreciating defects and deficiencies in mechanical and social devices.

The factor of *originality,* on the other hand, proved to be more general than had been expected. Tests requiring diverse evidences of *originality* remained together in defining the factor. Some were scored for uncommonness or unconventionality of responses; one was scored for cleverness of responses; and others were scored for responses showing remote associations or far-fetched ideas in connection with stimuli. Both the sensitivity-to-problems factor and the originality factor were being reexamined for degree of generality.

Other hypotheses pertain to the question of identity of pairs of factors found in different analyses. *Associational fluency,* found in the creativity analysis (Wilson et al., 1954), might be the same factor as the one called *facility with verbal relations* found in the evaluation analysis (Hertzka et al., 1954). *Redefinition* showed some possibility of identification with the

Air Force factor of *judgment* (Guilford & Lacey, 1947) in the creativity analysis but failed to show this linkage in the evaluation analysis. These points needed clarification and were expected to receive some clarification in this study.

Two factors found in the evaluation analysis were given special attention in this study—*facility with verbal relations* and *verbal classification.* There was some doubt whether these should be regarded as evaluative abilities at all. The first of these was found related to a relatively long list of verbal tests. It might even have been identified as the factor of *verbal comprehension,* except for the fact that another factor qualified for that identification. The leading test for *facility with verbal relations* was Controlled Associations, which had been included to serve as a marker for the factor of *associational fluency.* The obtained factor might have been a confounding of *associational fluency* with *eduction of conceptual relations,* the latter then regarded as a reasoning ability. In the study being reported we should have the opportunity to test these different interpretations, and, in fact, to see whether the same factor would emerge as such a second time.

There was also doubt as to the status of *verbal classification.* In the first reasoning analysis (Green et al., 1953), we entertained the hypothesis that there might be a separate ability to see identical elements in verbal entities. The common observation that classes are formed and class concepts are born would lend reasonableness to such a hypothesis. The hypothesis was proposed in connection with a group of ideas about inductive reasoning. Not enough classifying tests were included in the first reasoning analysis to determine whether there is a classifying ability distinct from an ability to see relations. So far as we know, then, both kinds of tests might be loaded with the same factor—*eduction of conceptual relations.* Thus, the factor called *verbal classification* in the evaluation analysis might have been *eduction of conceptual relations,* or it might have represented a new factor of ability to classify meaningful material. This study was expected to determine the status of the classifying-ability factor; whether or not it is separate from the relations-educing factor.

A general logical problem arose in this study owing to the fact that we introduced a number of tests that involved the act of naming. In previous studies of tests calling for the discovery of relations, patterns, and classes, we had generally asked for multiple-choice responses indicating that these had been discovered from the fact that the examinee did something revealing. This is an indirect way for the examinee to show that he has cognized the relation, pattern, or class. The additional step or steps might well bring additional common factors into the test variances. By asking the examinee to name or describe the relation, pattern, or class, it was thought that we should obtain a more direct indication of successful cognitions.

It soon occurred to us that naming, itself, is an additional act and might also generate additional common factors. Another aspect of this problem would be whether, if the act of naming does entail something new in the way of factors, there would be one new naming factor, in common to all of the naming tests, or there would be several naming factors, each parallel to one of the discovery factors—that for discovering perceptual relations, that for conceptual relations, and that for conceptual patterns—and perhaps, also, parallel to other factors. Considering all the naming tests included in the battery, there were possibilities for all the way from none to as many as five naming, or verbalizing, factors to appear.

### *Statement of the Hypotheses*

1. *Eduction of perceptual relations* had been found in tests composed of figural material and not in tests composed of meaningful words. Two kinds of figural tests were involved: those involving seeing simple relationships as to form, position, shading, and other properties and others involving the classification of figures according to their properties. We therefore tested the hypothesis that there is a single ability involving both relations and classes

of figural material or that there are two hypothetical factors: (*a*) seeing figural relations and (*b*) seeing figural classes. A hypothesis tested incidentally was whether tests involving the grouping of letters and spelling of words would also be related to one or both factors.

2. *Eduction of conceptual relations* had had relatively low loadings in previous analyses, but there was little doubt of its existence as a factor. As in the case of the preceding factor, however, there was the question of whether one factor would suffice or whether it would take two: (*a*) seeing conceptual relations and (*b*) seeing conceptual similarities or seeing classes.

3. *Eduction of conceptual patterns* seemed to call for something more than simple relationships. The term "patterns" had been used because it is sufficiently general to include principles, systems, rules, and perhaps trends. It had been designated as "conceptual" at the time this study was planned because the patterns were based upon combinations of elements in which figural properties were of little or no importance. Three alternative hypotheses were entertained in this study: (*a*) seeing patterns, (*b*) seeing rules or principles, and (*c*) seeing trends.

4. *Eduction of correlates* was defined as the ability to find something that fits into a given relationship. Both conceptual and nonconceptual tests had been previously loaded on the factor. One important question was whether, if given the opportunity, conceptual and nonconceptual tests would split into two groups, indicating two distinct but parallel abilities, as we had seen in a number of places. The leading test for the factor previously had included items involving relations between meanings and items involving relations between word structure or spelling. In the present study the two kinds of items were put in separate tests. The two alternative hypotheses were: (*a*) finding something to fit a perceptual relationship and (*b*) finding something to fit a conceptual relationship.

5. *Symbol manipulation* was defined as the ability to manipulate symbols according to given rules. In another analysis a factor called "symbol substitution" was defined as the ability to substitute symbols according to rules. We had the question as to whether there is one factor or two. With added tests included in this study we had the opportunity to answer this question and also to determine the main properties of either one or two factors. The hypotheses were: (*a*) symbol manipulation and (*b*) symbol substitution.

6. *Verbalizing ability* was suggested as a new factor (or group of factors), in accordance with the earlier discussion. We had eight tests in the battery that involve the naming or describing of discovered relations, of similarities or identical elements, of rules or principles, and of trends. We thought that there might be as many as five factors and we have accordingly five hypotheses: (*a*) naming perceptual relations, (*b*) naming conceptual relations, (*c*) naming classes, (*d*) stating rules or principles, and (*e*) describing trends. Either *c* or *d* might divide two ways, depending upon the test content, whether figural or verbal.

7. *Sensitivity to problems* had been found limited to two tests, involving mechanical devices and social institutions, respectively, in the creativity analysis. Tests were added to determine whether the factor generalizes at all to nonmechanical and nonsocial areas. The only hypothesis tested here is with regard to the generality of the factor.

8. *Associational fluency* had been defined as the ability to produce words to meet specific requirements of meaning. The test Controlled Association, which called for 12 synonymous responses to each item, strongly determined this factor in the creativity analysis. Another form of the same test, which called for only three responses to each item, failed to segregate the same factor in the evaluation analysis. Both forms of the test were included in the present study. We also had two tests that called for only one word per item. The two hypotheses were: (*a*) producing one or two words to fit a given meaning and (*b*) producing several words to fit a given meaning.

It might be found that a single factor would have both properties or two separate factors might be found.

9. *Originality* was being tested for degree of generality, as stated earlier. Originality tests had been constructed along three lines, involving the production of uncommon, remote, or clever responses, respectively. All three kinds of tests had been loaded on the factor, but in this study tests were added in ways that should have given the opportunity for two or even three originality factors to emerge. The three hypotheses were: (*a*) production of remote responses, (*b*) production of uncommon responses, and (*c*) production of clever responses.

10. *Redefinition* had been a rather weak factor in two prior analyses. It was defined as the ability to shift the function of an object or part of an object and use it in a new way. In this study we sought to determine whether the factor could be verified and whether it could be distinguished from the *judgment* factor. As things turned out, conditions were not favorable for answering the second question.

11. *Facility with verbal relations,* as indicated earlier, was a factor of uncertain status. In this study we were merely interested in determining whether tests previously defining the factor would hang together as before or whether they would define two or more other factors, such as *associational fluency* and *eduction of conceptual relations.*

12. *Verbal classification,* found in one of our previous analyses, offered two logical possibilities. The factor was defined as the ability to appraise poorly defined verbal relationships. Here relation to a category or class is actually implied. The "poorly" was added because tests of the same character but having more clear-cut, logical relationships did not have loadings on the factor. An apparently similar factor found by Adkins and Lyerly (1951) was defined as an ability to perceive abstract similarities. The two hypotheses are: (*a*) appraising poorly defined verbal relationships and (*b*) seeing conceptual similarities.

### *Summary of the Hypotheses and Reference Factors*

For convenience, the various hypotheses just stated are presented in outline form to serve as ready references in connection with later discussion of tests and factors:

1. Eduction of perceptual relations
    (*a*) Seeing perceptual relations
    (*b*) Seeing perceptual similarities
2. Eduction of conceptual relations
    (*a*) Seeing conceptual relations
    (*b*) Seeing conceptual similarities
3. Eduction of conceptual patterns
    (*a*) Seeing conceptual patterns
    (*b*) Seeing rules or principles
    (*c*) Seeing trends
4. Eduction of correlates
    (*a*) Finding something to fit a given perceptual relation
    (*b*) Finding something to fit a given conceptual relation
5. Symbol manipulation
    (*a*) Symbol manipulation
    (*b*) Symbol substitution
6. Verbalizing ability
    (*a*) Naming perceptual relations
    (*b*) Naming conceptual relations
    (*c*) Naming classes
    (*d*) Stating rules or principles
    (*e*) Describing trends
7. Sensitivity to problems
8. Associational fluency
    (*a*) Producing one or two words to fit a given meaning
    (*b*) Producing several words to fit a given meaning
9. Originality
    (*a*) Producing remote responses
    (*b*) Producing uncommon responses
    (*c*) Producing clever responses
10. Redefinition
11. Facility with verbal relations
12. Verbal classification
    (*a*) Appraising poorly defined verbal relations
    (*b*) Seeing conceptual similarities

Since many tests designed to test the hypotheses were known to contain or were suspected of containing common variances with factors outside this list, reference tests were added to the battery to isolate these sources of variance. The reference factors, numbered in sequence with those already listed, are:

13. Ideational fluency
14. General reasoning
15. Logical evaluation

16. Verbal comprehension
17. Numerical facility
18. Judgment

## THE TEST BATTERY

The hypotheses were the main consideration in determining the kinds of tests that were selected for inclusion in this study. In those cases in which tests had to be adapted or new tests had to be constructed to fit the hypotheses, several other considerations were kept in mind. Each test was divided into at least two separately timed, comparable parts for purposes of convenient and meaningful estimation of reliability. Variance due to personal experiences of examinees was minimized as much as possible. An attempt was made to keep the factorial complexity of tests as low as possible. Before the assembly of the battery, new or adapted tests were pretested on samples of college students. On the basis of these results, 57 experimental tests were selected for inclusion in the analysis. It had been planned to include several of the Air Force tests, which are given to air cadets routinely for classification purposes, to serve as markers for some of the reference factors. But by the time our battery could be administered, the Air Force had discontinued separate scoring of its classification tests, hence the test scores were not available to us.

The tests are described in the following section. For convenience the tests are listed in alphabetical order. For every test the nature of the task is described and for most a sample item is given. Other information includes the number of separately timed parts, the number of items per part, and the working time. The code numbers of the tests indicate the following information. The first letter, R, C, E, or P, indicates reasoning, creativity, evaluation, or planning, respectively. The second letter (or pair of letters) stands for a specific hypothesis. Next comes the number of the test in that category, 01, 02, etc. The last letter indicates the form of the test, A meaning the first form, B the second, and so on. The uncoded tests were taken over from batteries given before the coding system was instituted.

### *Description of Tests*[4]

*1. Apparatus Test—CS01B.* A list of 20 implements is presented. The *E*'s (examinee's) task is to suggest two improvements for each of them.
Sample item:

Suggest two improvements for the telephone.

1. *A device to record messages when no one is at home.*
2. *Luminous dials to operate in the dark.*

Parts, 2. Items per part, 10. Working time, 14 min.
hfc,[5] 7.

*2. Associations III—CN05A.* The items consist of pairs of words. The *E*'s task is to think of a single word that is similar in meaning to both the given words. Since the given words are not synonyms, the word that *E* supplies must have a different meaning in relation to each of the given words.
Sample item:

recline __*lie*__ deceive

The correct answer is "lie" since it has a meaning similar to both given words.

Parts, 2. Items per part, 15. Working time, 12 min.
hfc, 8*a*, 9*a*, 11.

*3. Associations IV—CN06A.* This test is made up of pairs of words like those in Associations III. In this test, however, *E*'s task is to think of a word that is associated with (not synonymous with) the given words and that has a different meaning in its relation to each of the given words.
Sample item:

jewelry __*ring*__ bell

A correct association word is "ring." It has a different meaning in its relation to each of the given words. It is a piece of jewelry and also the sound of a bell.

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[4] The authors gratefully acknowledge permission for test use and/or adaptation granted by the following authors or publishers: D. C. Adkins and D. E. Baier (Tests 31 and 56); R. I. Blakey (Tests 5 and 18); L. L. Thurstone (Tests 9, 10, 23, and 51); National Council for Social Studies (Test 12); and the Ronald Press Company (Test 25). Tests 13 and 44 were developed by the U. S. Air Force and Test 17 was developed by the U. S. Navy. Acknowledgment is also made for permission granted by the *Saturday Evening Post* and *Collier's* to use their cartoons in Test 4. We also wish to thank Constance D. Lovell for making available to us a number of classes in beginning psychology for preliminary experimental testing.

[5] hfc stands for hypothesized factor content. See preceding summary for key to the hypotheses.

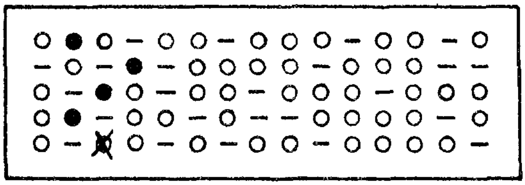
Parts, 2. Items per part, 15. Working time, 14 min. hfc, 9*c*.

4. *Cartoons—CN07A.* Each item is a cartoon taken from old issues of *Saturday Evening Post* or *Collier's*. The *E*'s task is to supply clever "punch" lines for each of the cartoons.

Parts, 2. Items per part, 8. Working time, 14 min. hfc, 9*c*.

5. *Circle Reasoning (no code number).* Each item consists of five rows of circles and dashes. One of the circles in each of the first four rows has been blackened according to a rule. The *E*'s task is to find the rule and then mark the circle that should be blackened in the last row.

Sample item:

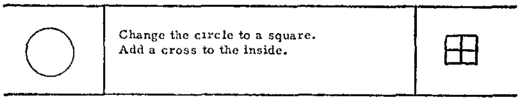


The second circle from the left in each row should be black; therefore, the second circle in the last row is marked to indicate that it is the one which should be black.

Parts, 1. Items per part, 15. Working time, 8 min. hfc, 3*a*.

6. *Completion of Figural Changes—REC05A.* In each item a figure is given. Written instructions as to how the figure changes are also given. The *E*'s task is to draw a figure that shows the results of all the changes.

Sample item:



If the circle is changed to a square and a cross is put into the square, then the figure that is drawn at the right is the correct answer.

Parts, 2. Items per part, 10. Working time, 10 min. hfc, 4*a*.

7. *Consequences Test—CF06A (low-quality score).* The *E* is to write what would happen if certain changes were suddenly to take place. He is to list as many different consequences or results of these changes as he can.

Sample item:

What would happen if all national and local laws were suddenly abolished?

1. *No more parking tickets*
2. *There would be more killing.*
3. *No more taxes*

Two scores are derived from this test. The low-quality score is the number of direct responses, i.e., those responses that describe direct or immediate consequences of the given changes.

Parts, 4. Items per part, 1. Working time, 8 min. hfc, 13.

8. *Consequences Test—CF06A (remoteness score).* The remoteness score is the second score that is derived from the Consequences Test. It is the number of remote responses, i.e., those responses that describe remote or far-reaching consequences of the given changes.

Parts, 4. Items per part, 1. Working time, 8 min. hfc, 9*a*.

9. *Controlled Associations—CAF01B.* In each item *E* is given a common word. His task is to write as many synonyms as possible for each word, 12 spaces being provided for each word.

Sample item:

GOOD: *right* *virtuous* *deserving*
*excellent* *noble* *pleasing*
*superior* *worthy* *creditable*
*commendable* *pious* *admirable*

Parts, 2. Items per part, 4. Working time, 14 min. hfc, 8*b*.

10. *Controlled Associations II—CAF02B.* The format of this test is the same as Controlled Associations, CAF01B, except that *E* may give only three synonyms for each given word.

Sample item:

ODD: *unusual*
*unique*
*queer*

Parts, 2. Items per part, 10. Working time, 6 min. hfc, 8*a*, 8*b*, 11.

11. *Correlate Completion II—REC01A.* Each item consists of two pairs of words and a single word. The *E*'s task is to supply a word that bears the same relation to the single word as the relation between the words in the first two pairs. The relation between the words in each pair is based on the structure of the words and not on their meanings.

Sample items:

1. am ma not ton tool *loot*
2. enrage rage correlate late about *bout*

Parts, 2. Items per part, 20. Working time, 12 min. hfc, 4*a*.

12. *Critical Evaluation—EL05A.* The statements of this test have been taken from the section of newspapers entitled "Letters to the Editor." It is *E*'s task to designate those statements (A) based primarily on emotion or prejudice, and those (B) showing reasoning and thought.

Sample items:

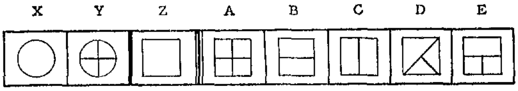
1. All people who drink hard liquor should have their driver's licenses taken away.
2. The police should revoke the licenses of those people who drive while drunk.

Answers: 1. A, 2. B.

Parts, 2. Items per part, 15. Working time, 5 min. hfc, 12*a*.

*13. Figure Analogies—RPR04A.* The *E*'s task is to select a figure that bears the same relation to the third figure as the second bears to the first.

Sample item:

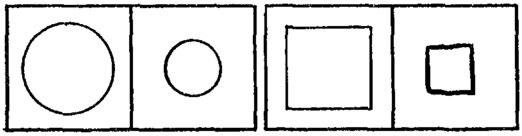


Answer: A.

Parts, 2. Items per part, 15. Working time, 10 min. hfc, 1*a*, 4*a*.

*14. Figure Analogies Completion (no code number).* This test is the same as Figure Analogies RPR04A except that *E* must draw the figure that completes the second pair in accordance with the relation given by the first pair.

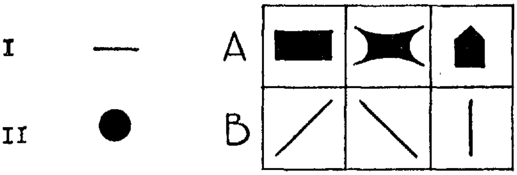
Sample item:



Parts, 1. Items per part, 15. Working time, 10 min. hfc, 4*a*.

*15. Figure Classification—EF01A.* Classes are defined by groups of three figures. Single figures have to be assigned to these classes in terms of common characteristics. There are three sets of five classes and five single figures have to be classified for each set.

Sample item:

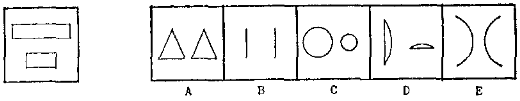


Answer: I - B, II - A.

Parts, 1. Items per part, 15. Working time, 6 min. hfc, 1*b*.

*16. Figure Matching—EF04A.* In each item a geometrical figure is given along with a set of five other figures. The *E*'s task is to select the figure from the set that has most in common with the key figure.

Sample item:

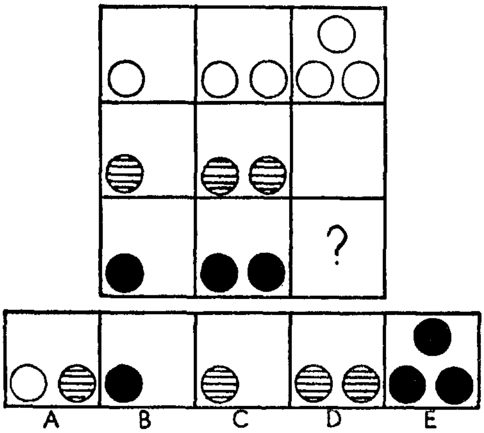


Answer: C.

Parts, 2. Items per part, 15. Working time, 14 min. hfc, 1*b*.

*17. Figure Matrix (no code number).* In each item nine squares are presented with figures that change in both directions. Some squares are left empty. The *E* indicates which one of five alternate figures goes in an indicated square.

Sample item:



Answer: E.

Parts, 1. Items per part, 15. Working time, 7 min. hfc, 1*a*.

*18. Form Reasoning (no code number).* In each item three familiar forms are given. In addition, a table showing how these forms can be combined is given. On the basis of this table, *E* is to find a form that is equal to the three given forms.

Table:

| | | | |
|---|---|---|---|
| ☆○=□ | ○☆=□ | ○✙=☆ | ✙○=☆ |
| □✙=△ | ✙□=△ | ☾✙=◇ | ✙☾=◇ |
| ☆✙=○ | ✙☆=○ | ◇○=✙ | ○◇=✙ |
| □○=☾ | ○□=☾ | ○☾=8 | ☾○=8 |

Sample item:

☆○✙ = ☆ □ ☾ △ ✙

The answer is found in the following manner. According to the table above, the first two figures—that is, the star and circle—are equal to a square. Now, if a square is put in place of the star and circle, then a square and a cross remain. According to the table a square and a cross are equal to a triangle. Therefore, the correct answer is a triangle.

Parts, 1. Items per part, 20. Working time, 2 min. hfc, 5*b*.

*19. Gestalt Transformation—CR03A.* In each item a problem is presented. The *E*'s task is to select from five given objects the one that would be most useful in solving the problem.

Sample item: TO START A FIRE

A. fountain pen B. onion C. pocket watch D. light bulb E. bowling ball

Best answer: C.

Parts, 2. Items per part, 10. Working time, 10 min. hfc, 10.

20. *Inference Test—RD03B.* Each item presents a statement of fact or opinion, such as might be found in a newspaper, and five alternate conclusions. The *E* indicates which of these can be drawn with most justification.

Sample item:

Most of the trees in the forest are green.

A. There are no yellow trees in the forest.
B. There are some yellow trees in the forest.
C. Some of the trees in the forest are green.
D. Green trees are the tallest in the forest.
E. Pine trees are green.

Answer: C.

Parts, 2. Items per part, 8. Working time, 10 min. hfc, 15.

21. *Inventive Verbal Relations—REC07A.* In each item a different relationship is stated. Two words are then given. The *E*'s task is to produce two words that bear the specified relationship to the given words.

Sample item:

(a) is the opposite of (b)

(a) black: (b) *white* :: (a) strong: (b) *weak*

Parts, 2. Items per part, 15. Working time, 8 min. hfc, 4*b*.

22. *Letter Grouping—RPS01A.* In each item four groups of four letters each are given. Three of the groups are alike in some way. The *E*'s task is to pick out the group of letters that is different from the other three.

Sample item:

AABC ACAD ACFH AACG

Parts, 2. Items per part, 20. Working time, 8 min. hfc, 1*b*.

23. *Letter Series—RCP03A.* Each item consists of a series of letters. The *E*'s task is to find the rule for the series and write the next two letters in the series.

Sample item:

E F E F E F E *F* *E*

Parts, 2. Items per part, 15. Working time, 8 min. hfc, 3*b*.

24. *Letter Triangle—RCP01B.* Each item consists of a series of letters arranged in triangular form with various letters left out. The *E*'s task is to determine which letter goes into the blank space indicated by the question mark.

Sample item:

a A. h
b c B. j
d e f C. g
? ___ D. f
______ E. a

Answer: C.

Parts, 2. Items per part, 8. Working time, 12 min. hfc. 3*a*.

25. *Logical Classification—EL07A.* This test consists of statements containing "ought." The *E* has to classify these statements in terms of categories, which are defined and for which examples are given.

Sample item:

You ought not to cross the street against the red light.

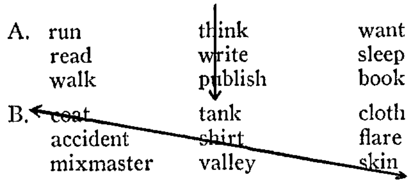
A. custom B. completeness C. safety D. utility E. welfare

Answer: C.

Parts, 2. Items per part, 25. Working time, 14 min. hfc, 10, 11, 15.

26. *Matrix Order—PR01A.* Each item consists of a 3 × 3 matrix of words. The *E*'s task is to draw a straight line through three words that represent a sequence in space or time. He is also to indicate the direction of the sequence by arrow heads.

Sample items:



Parts, 2. Items per part, 15. Working time, 18 min. hfc, 3*c*.

27. *Number Series—RCP05A.* In each item a series of numbers is given. The *E*'s task is to find the rule for the series and write a description of it in the given blank.

Sample item:

15 18 21 24 27 30 *+3*

Parts, 2. Items per part, 20. Working time, 12 min. hfc, 3*b*, 6*d*.

28. *Object Synthesis—CY01B.* In each item the names of two objects are given. The *E*'s task is to think of something that could be made by combining the two objects.

Sample item:

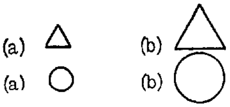
GIVEN: volley ball steel spring

Possible answer: punching bag.

Parts, 2. Items per part, 12. Working time, 10 min. hfc, 10.

29. *Perceptual Relations Naming—RPR03A.* In each item two pairs of figures are given. The *E*'s task is to state the relation that the first figure of each pair bears to the second.

Sample item:

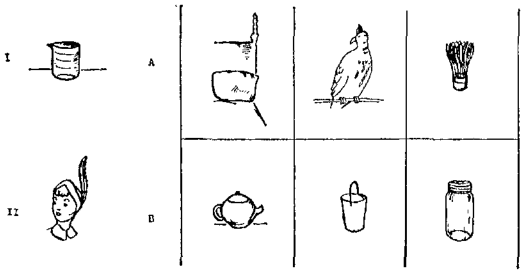


"a" is smaller than "b"

Parts, 2. Items per part, 14. Working time, 14 min. hfc, 1*a*, 6*a*.

*30. Picture Classification—EF03A.* Classes are defined by groups of three pictures each. The *E*'s task is to assign single pictures to these classes in terms of common characteristics.

Sample item:

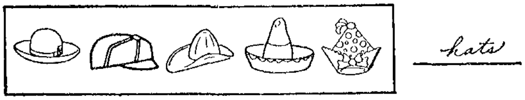


Answers: I - B, II - A.

Parts, 2. Items per part, 15. Working time, 13 min. hfc, *2b*, *12b*.

*31. Picture-Group Naming—RCS03A.* Each item is a group of five pictures of objects that are alike in some way. The *E*'s task is to provide a class name for each group.

Sample item:



Parts, 1. Items per part, 24. Working time, 6 min. hfc, *2b*, *6c*, *12b*.

*32. Plot Titles—CF02C (cleverness score).* In the Plot Titles test, four story plots are presented. The *E* is instructed to write as many clever titles as he can for each plot. The cleverness score is the number of responses that are rated clever.

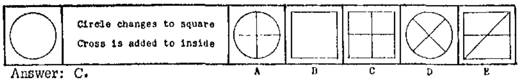
Parts, 4. Items per part, 1. Working time, 12 min. hfc, *9c*

*33. Plot Titles—CF02C (low-quality score).* The low-quality score is the number of responses that are rated "not clever."

Parts, 4. Items per part, 1. Working time, 12 min. hfc, 13.

*34. Prescribed Relations—RSM03B.* In each item one figure is given. Written instructions as to how the figure is to be changed are also given. The *E*'s task is to pick out from five given alternatives the figure that shows the results of all the changes.

Sample item:



Answer: C.

Parts, 2. Items per part, 10. Working time, 10 min. hfc, *4a*.

*35. Quick Response—CN01A.* This test resembles the conventional word-association test. A list of words is read to the examinees at the rate of one every five seconds. The *E* is instructed to write down the first word that comes to him.

The test is scored by assigning a weight to each response where weights are directly proportional to infrequency of occurrence in the population, and summing the weights.

Parts, 1. Items per part, 50. Working time, 4.2 min. hfc, *9b*.

*36. Remote Verbal Similarities—RCS02B.* In this test *E*'s task is to select a word from five alternatives that has most in common with a given word, where all connections are rather remote.

Sample item:

FATHER
A. candidate
B. second baseman
C. agitator
D. superintendent
E. salesman

Answer: D.

Parts, 2. Items per part, 15. Working time, 10 min. hfc, *9a*, *12a*.

*37. Seeing Deficiencies—PJ01A.* In each item a short description of a plan or activity is given. The *E*'s task is to point out how the plan is faulty.

Sample item:

A growing city discovers pressing needs to improve both its streets and its sewer systems. After due consideration, the council decides to work on the street-improvement program first. What is wrong with this plan?

*The streets will have to be torn up again for the sewer system.*

Parts, 2. Items per part, 10. Working time, 20 min. hfc, 7.

*38. Seeing Problems—CS06A.* In each item the name of a common object is given. The *E*'s task is to write down five problems that might arise in connection with the object.

Sample item:

CANDLE: A. *How to light it.*
B. *Keeping it from falling.*
C. *Keeping it from flickering.*
D. *How long will it burn.*
E. *What to do with the drippings.*

Parts, 2. Items per part, 6. Working time, 8 min. hfc, 7, 13.

*39. Seeing Trends—RI06A.* The items in this test consist of a group of words that tend to change progressively in some meaningful way. The *E*'s task is to discover the trend in the words.

Sample item:

Mouse rat lion pig cow horse elephant

*Animals become larger.*

Parts, 2. Items per part, 10. Working time, 10 min. hfc, *3c, 6e.*

*40. Seeing Trends II—RCP04A.* This test is similar to Seeing Trends RI06A. Each item consists of a group of words and *E*'s task is to find the trend in the words. In this test, however, the trend is based on the structure of the words rather than on the meaning of the words.

Sample item:

Anger bacteria camel dead excite

*The first letters go from "a" to "e"*

Parts, 2. Items per part, 12. Working time, 16 min. hfc, *3c, 6e.*

*41. Ship Destination (no code number).* Using a diagram and observing an increasing number of rules, *E* has to determine the distance between ships and ports. In addition to rules of distance, wind direction must be considered at the start of the test. Later the current direction, the strength of wind and current, and the heading of the ship must all be taken into account.

Parts, 1. Items per part, 48. Working time, 15 min. hfc, 14.

*42. Sign Changes—CX04B.* This test involves simple numerical operations in which *E* must substitute one arithmetic operation sign for another before performing the operation.

Sample item:

In the following problems wherever you see:

− replace it by ×

+ replace it by −

$3 - 6 = \underline{18}$

$6 + 2 = \underline{4}$

Parts, 3. Items per part, 8, 16, 16. Working time, 1.67 min. hfc, *5b.*

*43. Sign Changes II—RSM02A.* The items consist of simple arithmetic equations. In these equations the value on the left of the "equals" sign is not equal to the value on the right. The *E*'s task is to indicate which interchange of signs will make the two values equal.

Sample item:

$1 + 2 = 4 \times 1$

A. + and −
B. × and +
C. + and ÷
D. × and ÷
E. × and −

Answer: E.

Parts, 2. Items per part, 10. Working time, 14 min. hfc, *5a.*

*44. Similarities—RCS01A.* Each item consists of a pair of common objects. The *E*'s task is to write six ways in which the objects are alike.

Sample item:

Apple and Orange are alike

A. *sweet*
B. *round*
C. *have seeds*
D. *fruit*
E. *grow on trees*
F. *have skins*

Parts, 2. Items per part, 6. Working time, 10 min. hfc, *2b, 12b,* 13.

*45. Social Institutions—CS05A.* In each item the name of a social institution is given. The *E* is asked to list two improvements for each social institution that is given.

Sample item:

Marriage:

*Courses on marriage in schools.*

*Social approval of women proposing.*

Parts, 2. Items per part, 6. Working time, 10 min. hfc, 7.

*46. Syllogisms I—EL01A.* The items in this test represent 15 combinations of the four figures and four moods of the categorical syllogism. The *E* is required to state whether the conclusion is true or false in each case.

Sample item:

All soldiers are men.
Some citizens are soldiers.
Therefore, some citizens are men.

Answer: True.

Parts, 2. Items per part, 15. Working time, 10 min. hfc, 15.

*47. Symbol Manipulation II—RSM04A.* In each item a main statement, presented symbolically, is given along with several conclusions. Each conclusion consists of two parts. The *E*'s task is to indicate the truth or falsity of each conclusion on the basis of given definitions of the symbols.

Sample item:

"L" means "larger than"
"S" means "smaller than"
"E" means "equal to"
"NE" means "not equal to"

If xEy and yNEz, then:

1. xNEz and yEx
2. xSz and xLz

A. Both parts are true.
B. One part is true and the other part is indeterminate.
C. One part is true and the other part is false.
D. One part is false and the other part is indeterminate.
E. Both parts are false.

Answers: 1 - A, 2 - C.

Parts, 2. Items per part, 15. Working time, 10 min. hfc, *5a,* 15.

*48. Unusual Uses—CN04B.* The items are names of common objects. Each object has a common use, which is given. The *E* is asked to list other uses for which the object or parts of the object could serve.

Sample item:

A newspaper (used for reading)
1. *to start a fire.*
2. *to wrap garbage in.*
3. *to swat flies.*
4. *stuffing to pack boxes.*
5. *to line drawers or shelves.*
6. *to make up a kidnap note.*

Parts, 2. Items per part, 3. Working time, 10 min. hfc, 9*b*, 13.

*49. Verbal Analogies I—RCR01C.* This is a verbal-analogies test in which there was an attempt to make the relationship between the first pair of words relatively difficult to grasp and the analogy relatively easy to fulfill.

Sample item:

electricity: energy :: green: ______?

A. color B. red C. grass D. trees E. foliage

Answer: A.

Parts, 2. Items per part, 15. Working time, 12 min. hfc, 2*a*.

*50. Verbal Analogies Completion—REC08A.* This is a completion form of the verbal-analogies test.

Sample item:

cloth: dye :: house: *paint*

Parts, 2. Items per part, 25. Working time, 8 min. hfc, 4*b*.

*51. Verbal Classification—EL16A.* Vertical groups of eight words are flanked on either side by vertical groups of four words that define two classes. After deciding upon the nature of the defined classes, *E* goes down the center column of words, checking on the left if a word belongs in the class to the left, checking on the right if it belongs in the one on the right, and making no mark if the word does not belong in either class.

Sample item:

| | | | | |
|---|---|---|---|---|
| COW | | desk | √ | TABLE |
| HORSE | √ | sheep | | CHAIR |
| GOAT | | rocker | √ | BOOKCASE |
| DOG | | tree | | LAMP |
| | √ | cat | | |
| | | nose | | |
| | | dresser | √ | |
| | √ | donkey | | |

Parts, 2. Items per part, 40 (5 groups of 8). Working time, 8 min. hfc, 2*b*, 12*b*.

*52. Verbal Comprehension (no code number).* This test is Part I of the Guilford-Zimmerman Aptitude Survey (short form). It is a standard multiple-choice vocabulary test.

Parts, 1. Items per part, 40. Working time, 12 min. hfc, 16.

*53. Verbal Relations Naming—RCR02A.* Each item consists of two pairs of words. The *E*'s task is to write down the relation that the first word in each pair bears to the second.

Sample item:

(a) dwarf (b) giant
(a) bottle (b) barrel (a) *is smaller than* (b)

Parts, 2. Items per part, 25. Working time, 12 min. hfc, 2*a*, 6*b*.

*54. Vocabulary Completion—REC06A.* The *E*'s task is to write down a word that fits a given definition and that begins with a given letter.

Sample item:

A contest of speed..........(r) *race*

Parts, 2. Items per part, 40. Working time, 6 min. hfc, 8*a*, 16.

*55. Word Classification—EL17A.* The *E*'s task is to decide which word in a group of four does not belong.

Sample item:

A. horse B. cow C. man D. flower

Answer: D.

Parts, 2. Items per part, 20. Working time, 14 min. hfc, 2*b*, 12*b*.

*56. Word-Group Naming—RCS02B.* Each item consists of groups of five words. The *E*'s task is to write down a definitive name for each group of words.

Sample item:

knife pan bowl rolling pin strainer
*cooking utensils*

Parts, 2. Items per part, 15. Working time, 10 min. hfc, 2*b*, 6*c*, 12*b*.

*57. Word Groups—RPS02A.* Each item consists of a group of four words. The *E*'s task is to find out what the words in each group have in common. The things that the words have in common are structural rather than meaningful.

Sample item:

read retire rearming restless
*All words begin with "re"*

Parts, 2. Items per part, 15. Working time, 20 min. hfc, 1*b*, 3*b*, 6*c*.

## TESTING CONDITIONS

It had been originally planned that this battery of tests would be administered to a single sample. Arrangements had been made in December of 1953 to administer the battery to aircrew trainees at Lackland Air Force Base, San Antonio, Texas. The total testing time amounted to 12 hours.

During the interval between the time the arrangements were made and the test material was shipped, conditions had changed at Lackland Air Force Base. Twelve hours of testing time could not be worked into the schedule of the trainees and a maximum of six hours was offered. The solution was to divide the battery into three smaller ones, Batteries A, B, and C, each taking six hours. It was later learned that the Air Force could not work Battery B into its schedule so arrangements were made to have it administered to naval air cadets at Pensacola, Florida.

An overlapping of the batteries enabled us still to test most of the hypotheses, although with some loss of information. There was something gained by the fact that some factors could come out in more than one analysis, hence there was some opportunity for replication of results. Two tests, Nos. 20 and 46, had to be omitted entirely, which meant loss of two tests for the factor of *logical evaluation.*

### *Test Administration*

In setting up the batteries, special attention was given to the order of administration of the tests, seeing that the tests designed for a certain hypothesis were not given consecutively. Administration manuals provided complete information to test administrators. From both testing locations it was reported that no special problems arose during the test administration and that the examinees seemed well motivated.

### *The Samples*

Batteries A and C were administered at Lackland Air Force Base to 205 and 215 aircrew trainees, respectively, in groups of approximately 100 each, during the month of August, 1954. Battery B was administered to 225 examinees in groups of 30 to 60 every two weeks during the months of October through December, 1954.[6] At both locations the aviation cadets were typically in their early 20's, above the average of the population as to general intelligence, and had education of the level of high-school graduation or beyond.

Some of the examinees had to be eliminated from the study because of incomplete information regarding them. As a result, the samples numbered 201 for Battery A, 219 for Battery B, and 210 for Battery C.

## TREATMENT OF THE DATA

### *Scoring*

The responses to 20 of the tests were recorded on IBM answer sheets by the examinees. The answer sheets were machine scored and the scoring checked. All scores involved a correction for guessing. The remaining tests being of completion form were scored by hand and the scoring checked.

### *Test Statistics*

Reliabilities were estimated using a sample of 200. Alternate forms and odd-even estimates were made for 49 of the tests. For two tests the Kuder-Richardson Formula 20 was used. Other estimates were obtained from earlier studies. The various estimates of reliability and their sources are given in Table A,[7] along with means and standard deviations of the various test variables.

### *The Factor-Analysis Procedures*

After checking upon score distributions, which all approached the normal form, Pearson product-moment correlation coefficients were computed among the tests for the three batteries. These data are presented in Tables B, C, and D.

Twelve factors were extracted from each of the correlation matrices, using Thurstone's complete centroid method. The loadings of the last centroid factors were all smaller than .20 in absolute value and all residuals were less than .05 in absolute value. The unrotated factor matrices are presented in Tables E, F, and G.

The axes were rotated by Zimmerman's (1946) graphic, orthogonal method. The three criteria used to guide the rotations were simple structure, positive manifold, and psychological meaningfulness. The rotated factor matrices are presented in Tables 1, 2, and 3.

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[6] Grateful acknowledgment is made to the Personnel Research Laboratory, HRRC, Lackland AFB, Texas, and to the Aviation Psychology Laboratory, U. S. Naval Air Station, Pensacola, Florida, for making this testing possible. In particular, the authors wish to thank Lloyd G. Humphreys and J. W. Bowles at Lackland and Wilse B. Webb at Pensacola. In addition, the authors wish to thank the military and civilian personnel who acted as test administrators and proctors.

[7] Tables hereinafter designated Tables A-G have been deposited with the American Documentation Institute. Order Document No. 5958 from ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C., remitting in advance $1.25 for microfilm or $1.25 for photocopies. Make checks payable to Chief, Photoduplication Service, Library of Congress.

## TABLE 1

### ROTATED FACTOR MATRIX—BATTERY A

| | A<br>V | B<br>GR | C<br>PR | E<br>CR | F<br>VC | G<br>EP | H<br>EC | J<br>SM | K<br>SS | M<br>CC | U<br>(d) | $R_1$ | $h^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5. | −.01 | .08 | .14 | .13 | .08 | .44 | .23 | .01 | −.06 | .09 | −.01 | −.28 | .39 |
| 6. | .29 | .10 | .40 | .12 | .05 | .15 | .31 | .18 | .17 | .17 | .28 | .09 | .57 |
| 11. | .04 | .17 | .11 | .17 | .24 | .25 | .42 | .17 | .17 | .31 | .19 | .05 | .56 |
| 12. | .39 | .18 | −.09 | .06 | .10 | .03 | −.02 | −.04 | .29 | .04 | −.01 | −.27 | .37 |
| 13. | .18 | .27 | .54 | .16 | .15 | .29 | .25 | .07 | .08 | −.02 | .05 | .14 | .63 |
| 14. | .12 | .18 | .33 | .17 | −.01 | .07 | .53 | −.02 | −.02 | −.03 | .26 | .19 | .58 |
| 16. | .13 | −.12 | .00 | −.10 | .13 | .26 | .04 | −.12 | .14 | .02 | .09 | .28 | .25 |
| 17. | .12 | .19 | .39 | −.03 | .13 | .27 | −.01 | .03 | −.10 | .14 | .09 | .10 | .34 |
| 18. | .01 | .25 | .20 | .15 | −.08 | .16 | .08 | .02 | .53 | .07 | −.04 | .03 | .45 |
| 21. | .41 | .09 | .14 | .23 | .12 | .11 | .18 | .14 | .23 | .51 | .13 | −.04 | .66 |
| 23. | .08 | .41 | .14 | .15 | .18 | .36 | .40 | .15 | .14 | .27 | .00 | .04 | .66 |
| 24. | .11 | .08 | .17 | .20 | −.02 | .38 | .33 | .26 | .02 | .09 | .07 | .03 | .42 |
| 26. | .42 | .02 | .05 | .03 | .10 | .08 | .21 | .19 | −.04 | .20 | .07 | .10 | .33 |
| 27. | .02 | .36 | .11 | .04 | .22 | .32 | .16 | .43 | .32 | .20 | −.03 | .15 | .67 |
| 29. | .03 | .29 | .45 | .13 | .11 | .17 | .31 | .09 | .16 | .30 | .01 | −.07 | .57 |
| 30. | .28 | −.05 | .28 | .37 | .15 | .17 | .25 | .20 | .09 | .00 | −.06 | −.20 | .50 |
| 34. | .07 | .26 | .27 | .29 | .21 | .14 | .12 | .20 | .07 | .01 | .41 | .08 | .53 |
| 39. | .17 | .10 | −.04 | .19 | .00 | .21 | .08 | −.06 | .05 | .29 | .59 | .00 | .57 |
| 40. | .09 | .11 | .10 | .29 | .24 | .11 | .31 | .12 | .26 | .28 | .14 | .17 | .49 |
| 41. | .04 | .61 | .06 | .18 | .00 | .07 | .20 | .07 | .03 | .06 | .01 | .03 | .46 |
| 42. | .08 | .22 | −.01 | .12 | −.01 | −.01 | .21 | .19 | .65 | .05 | .04 | −.26 | .64 |
| 43. | −.06 | .37 | .11 | .14 | .06 | .07 | .28 | .39 | .09 | .07 | .21 | −.06 | .47 |
| 47. | .08 | .23 | .16 | .13 | .24 | .08 | .12 | .43 | .08 | .10 | .26 | .07 | .45 |
| 49. | .49 | .23 | .16 | .48 | .04 | −.02 | .21 | .13 | .02 | .04 | .19 | .21 | .69 |
| 50. | .38 | .12 | .28 | .38 | .29 | .16 | .13 | .02 | −.05 | .35 | .15 | .00 | .66 |
| 51. | .14 | .21 | .13 | .30 | .32 | .09 | .14 | .06 | .07 | .29 | .19 | −.05 | .43 |
| 53. | .28 | .19 | .24 | .29 | .04 | .16 | .13 | .18 | .11 | .54 | .01 | −.09 | .64 |
| 55. | .42 | .09 | .04 | .20 | .45 | −.01 | .28 | .03 | .05 | .05 | .09 | .26 | .59 |

TABLE 2

Rotated Factor Matrix—Battery B

|  | A | C | D | E | F | I | L | M | P |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | V | PR | PC | CR | VC | SR | NA | CC | AF | $R_2$ | $R_3$ | $R_4$ | $h^2$ |
| 2. | .31 | .12 | .09 | .04 | .19 | .16 | .20 | .18 | .46 | .20 | −.01 | −.04 | .51 |
| 3. | .12 | .11 | .20 | .13 | .16 | −.09 | .17 | .02 | .40 | .21 | .27 | −.15 | .45 |
| 10. | .28 | −.04 | .05 | .16 | .27 | .12 | .14 | .03 | .48 | −.13 | .00 | .05 | .47 |
| 11. | .14 | .20 | .25 | .22 | .10 | .50 | .06 | .44 | .27 | −.01 | .06 | .03 | .71 |
| 12. | .37 | −.06 | −.12 | .14 | −.01 | .12 | .28 | −.07 | .11 | −.10 | .19 | .09 | .34 |
| 13. | .10 | .58 | .18 | .28 | .05 | .21 | .18 | .19 | −.04 | −.11 | .08 | −.16 | .62 |
| 15. | .18 | .30 | .37 | .04 | .10 | .00 | .06 | .14 | .14 | −.05 | −.13 | .04 | .33 |
| 16. | .08 | .28 | .17 | .00 | .12 | .14 | −.10 | .07 | .00 | −.28 | .06 | −.13 | .26 |
| 17. | .17 | .55 | .13 | −.02 | −.08 | .17 | .13 | .07 | −.04 | .04 | −.03 | .11 | .42 |
| 21. | .53 | .08 | .19 | .05 | .11 | .04 | .29 | .47 | .20 | −.08 | .24 | .00 | .75 |
| 22. | −.07 | .25 | .29 | .07 | .17 | .56 | .27 | .14 | .24 | −.12 | .03 | −.05 | .67 |
| 29. | .29 | .19 | .06 | −.07 | .15 | .39 | .22 | .34 | −.01 | .00 | .02 | −.08 | .47 |
| 30. | .15 | .02 | .40 | .24 | .10 | .24 | .22 | −.09 | .08 | .06 | −.15 | −.05 | .40 |
| 31. | .12 | −.08 | .33 | .05 | .07 | .08 | .38 | .21 | .15 | −.01 | .15 | .15 | .40 |
| 36. | .32 | .15 | .25 | .09 | .12 | −.05 | .01 | −.05 | .14 | −.02 | .29 | .08 | .33 |
| 39. | .29 | .03 | −.07 | −.03 | .19 | .14 | .34 | .00 | .02 | −.08 | −.20 | −.07 | .31 |
| 40. | .20 | .15 | .04 | .15 | .17 | .42 | .08 | .19 | .23 | −.03 | .09 | .12 | .41 |
| 49. | .39 | .14 | .28 | .43 | .13 | .28 | .00 | .07 | −.09 | −.05 | .08 | −.01 | .55 |
| 50. | .43 | .22 | .09 | .37 | .15 | .08 | .22 | .41 | .17 | −.05 | .04 | −.05 | .66 |
| 51. | .20 | .23 | .18 | .34 | .40 | .04 | .19 | .20 | .18 | −.02 | −.02 | .03 | .51 |
| 52. | .79 | .05 | .01 | .15 | .08 | .12 | −.03 | .11 | .10 | −.19 | .05 | .09 | .74 |
| 53. | .28 | .12 | −.04 | .10 | .28 | .18 | .32 | .33 | .16 | −.02 | .11 | .20 | .50 |
| 54. | .40 | −.09 | .20 | .11 | .16 | .20 | .23 | .44 | .41 | .04 | −.12 | −.06 | .72 |
| 55. | .39 | .00 | .29 | .20 | .40 | .09 | −.10 | .13 | .00 | .05 | .21 | −.01 | .52 |
| 56. | .31 | −.07 | .17 | .29 | .38 | .04 | .36 | .13 | .00 | −.12 | .05 | −.02 | .52 |
| 57. | .22 | .11 | .28 | .22 | .29 | .38 | −.09 | .19 | .27 | .12 | .09 | −.17 | .58 |

TABLE 3

Rotated Factor Matrix—Battery C

| | A | I | L | N | O | P | Q | R | S | T | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | SR | NA | SP | Pe | AF | O | Re | IF | SX | $R_5$ | $R_6$ | $h^2$ |
| 1. | −.11 | −.03 | .05 | .45 | .51 | .20 | .17 | −.03 | .24 | .22 | .01 | .03 | .65 |
| 2. | .42 | .00 | .21 | −.05 | −.09 | .36 | .12 | .35 | −.08 | .20 | .12 | −.20 | .60 |
| 3. | .29 | .15 | .24 | −.06 | −.08 | .47 | .02 | .24 | .00 | −.04 | .07 | −.24 | .52 |
| 4. | .18 | −.05 | .10 | .04 | .27 | .18 | .47 | .25 | .16 | −.05 | .00 | .20 | .50 |
| 7. | .07 | .08 | −.10 | .09 | .24 | .03 | .06 | .06 | .58 | .24 | −.09 | .08 | .50 |
| 8. | .16 | .29 | .08 | .23 | .12 | .22 | .32 | −.08 | .34 | .41 | .03 | −.09 | .63 |
| 9. | .27 | .13 | .04 | .04 | .28 | .56 | .30 | .01 | .19 | .23 | .15 | .01 | .69 |
| 10. | .29 | .09 | .02 | .28 | .27 | .61 | .19 | −.05 | .18 | .27 | .03 | .13 | .78 |
| 19. | .05 | −.03 | .11 | −.06 | −.08 | .26 | .15 | .48 | −.11 | .11 | .03 | .10 | .38 |
| 22. | .00 | .49 | .27 | .28 | −.07 | .26 | .06 | .19 | .09 | −.02 | .20 | −.08 | .56 |
| 25. | .39 | .17 | .01 | .10 | .10 | .05 | .21 | .44 | −.18 | .11 | .08 | −.18 | .52 |
| 28. | .11 | −.02 | .40 | −.05 | .29 | .16 | .26 | .06 | .18 | .40 | .09 | −.08 | .56 |
| 31. | .11 | .17 | .37 | .29 | .07 | .28 | .04 | .19 | −.07 | .12 | −.08 | .02 | .41 |
| 32. | .21 | .25 | .14 | .06 | .15 | .16 | .43 | .04 | −.04 | .01 | −.18 | −.02 | .40 |
| 33. | −.12 | −.04 | −.02 | .12 | .20 | .04 | .06 | −.05 | .60 | .01 | −.21 | −.15 | .51 |
| 35. | .02 | −.11 | −.17 | .14 | .01 | −.01 | .18 | −.15 | .24 | −.11 | .16 | −.22 | .26 |
| 36. | .22 | .07 | .29 | .01 | .14 | .02 | −.08 | .34 | .05 | .00 | .22 | −.05 | .33 |
| 37. | .15 | .11 | .20 | .39 | −.03 | .07 | .23 | .40 | .00 | .21 | .02 | .17 | .52 |
| 38. | .13 | .13 | −.04 | .50 | .40 | .17 | .27 | .00 | .14 | .17 | .05 | −.27 | .67 |
| 44. | .19 | .10 | −.01 | .24 | .48 | .28 | .19 | .23 | .26 | .10 | .10 | −.06 | .59 |
| 45. | .18 | .06 | .13 | .38 | .50 | .16 | .24 | .00 | .27 | .10 | −.20 | .09 | .66 |
| 48. | .03 | .07 | .13 | .05 | .48 | .25 | .35 | .13 | .14 | .31 | .10 | −.13 | .60 |
| 52. | .64 | .12 | .24 | .05 | .02 | .13 | .16 | .13 | −.14 | −.04 | .07 | .07 | .57 |
| 54. | .44 | .12 | .24 | .18 | −.05 | .33 | .23 | .24 | .20 | .03 | .17 | .16 | .62 |
| 56. | .37 | .24 | .46 | .07 | .28 | .22 | .04 | .11 | −.07 | −.02 | .09 | −.04 | .57 |
| 57. | −.04 | .49 | −.02 | .00 | .24 | .17 | .07 | .29 | −.03 | .05 | .09 | .07 | .43 |

### INTERPRETATION OF THE FACTORS

The factors will be discussed roughly in order of the hypotheses listed earlier. The interpretations rest principally upon tests with factor loadings of .30 or greater. The names and numbers of the tests are listed preceding the discussion for each factor. Following the names of the tests are three columns labeled A, B, and C representing the three batteries. Factor loadings .30 or greater are listed opposite the name of the test in the column representing the battery in which the factor appeared. If a test had a loading of .30 or greater on a particular factor in one battery and one less than .30 in another battery on the same factor, both loadings are listed. In parentheses are loadings .30 or greater on other factors. A dash in the column indicates that the test was not in the particular battery. A plus sign indicates that the test was in the battery but that the factor under discussion did not appear in that battery.

The first two factors to be discussed are reference factors.

FACTOR A. VERBAL COMPREHENSION (V)

| | | A | B | C |
|---|---|---|---|---|
| 49. | Verbal Analogies I | .49 (.48 CR) | .39 (.43 CR) | — |
| 55. | Word Classification | .42 (.45 VC) | .39 (.40 VC) | — |
| 26. | Matrix Order | .42 | — | — |
| 21. | Inventive Verbal Relations | .41 (.51 CC) | .53 (.47 CC) | — |
| 12. | Critical Evaluation | .39 | .37 | — |
| 50. | Verbal Analogies Completion | .38 (.38 CR, .35 CC) | .43 (.37 CR, .41 CC) | — |
| 52. | Verbal Comprehension | — | .79 | .64 |
| 54. | Vocabulary Completion | — | .40 (.44 CC, .41 AF) | .44 (.33 AF) |
| 36. | Remote Verbal Similarities | — | .32 | .22 (.34 Re) |
| 56. | Word-Group Naming | — | .31 (.38 VC, .36 NA) | .37 (.46 NA) |
| 2. | Associations III | — | .31 (.46 AF) | .42 (.36 AF, .35 Re) |
| 25. | Logical Classification | — | — | .39 (.44 Re) |

It was expected that some of the tests designed for this study would contain appreciable amounts of *verbal-comprehension* variance in spite of the fact that an effort was made to keep to a low vocabulary level. The relatively large number of tests in the list above indicates that this is the case.

FACTOR B. GENERAL REASONING (GR)

| | | A | B | C |
|---|---|---|---|---|
| 41. | Ship Destination | .61 | — | — |
| 23. | Letter Series | .41 (.36 EP, .40 EC) | — | — |
| 43. | Sign Changes II | .37 (.39 SM) | — | — |
| 27. | Number Series | .36 (.32 EP, .43 SM, .32 SS) | — | — |

Ship Destination was put into Battery A as a reference test for *general reasoning* which had appeared in all four of the previous studies. According to most recent information (Kettner, Guilford, & Christensen, 1956), *general reasoning* is best defined as the ability to comprehend or to structure problems in preparation for solving them.

FACTOR C. EDUCTION OF PERCEPTUAL RELATIONS (PR)

| | | A | B | C |
|---|---|---|---|---|
| 13. | Figure Analogies | .54 | .58 | — |
| 29. | Perceptual Relations Naming | .45 (.31 EC, .30 CC) | .19 (.39 SR, .34 CC) | — |
| 6. | Completion of Figural Changes | .40 (.31 EC) | — | — |
| 17. | Figure Matrix | .39 | .55 | — |
| 14. | Figure Analogies Completion | .33 (.53 EC) | — | — |
| 15. | Figure Classification | — | .30 (.37 PC) | — |

This factor is the first in the list of factors being studied in this investigation. There were three tests listed under Sub-hypothesis 1*a* (seeing perceptual relations) —Figure Analogies, Figure Matrix, and Perceptual Relations Naming. All have significant loadings on this factor in both batteries (except Perceptual Relations Naming which has a significant loading only in Battery A). For this reason this factor is called *eduction of perceptual relations* and is defined as the ability to see perceptual relations.

Three other tests have significant loadings on the factor. One of these is Figure Analogies Completion. This test probably should have been included under Sub-hypothesis 1*a*, since the examinee must discover the relation between two figures before he draws a figure that fits the relation. As such it is reasonable to expect that a portion of the variance of this test would be accounted for by a seeing-relations factor. Another test loaded on this factor is Completion of Figural Changes. It was expected that the major portion of the variance of this test would be accounted for by an *eduction-of-correlates* factor since the relationship is given and the examinee has only to draw a figure to fit the relationship. The final test on this factor is Figure Classification which is a "seeing similarities" test. It is possible that relationships between figures have to be taken into account in classifying them.

In both reasoning studies the list of tests for *eduction of perceptual relations* had contained tests in which seeing similarities seemed to be the main feature along with tests in which seeing relations seemed to be the main feature. One hypothesis tested in this study was that each of these two types of tests would form a factor of its own if given a chance. This seems to be the case, since Factor C involves seeing perceptual relations and Factor D involves seeing perceptual similarities.

FACTOR D. PERCEPTUAL CLASSIFICATION (PC)

| | A | B | C |
|---|---|---|---|
| 30. Picture Classification | + | .40 | — |
| 15. Figure Classification | — | .37 (.30 PR) | — |
| 31. Picture-Group Naming | — | .33 (.38 NA) | + |

This factor is called *perceptual classification* and is defined as the ability to see similarities in perceptual material. It had been expected that two of the tests—Figure Classification and Figure Matching—under Sub-hypothesis 1*b*(seeing perceptual similarities), would define the factor if it emerged. Figure Matching had low inter-correlations with all other tests and as a result has no significant loading on any factor in this study. Figure Classification does have a significant loading on the factor.

Two other tests were listed under Sub-hypothesis 1*b*. They are tests of the type that have been called "structural" in this project. Structural tests are defined as those that involve simple symbols, letters, or numbers. The hypothesis that "seeing similarities" in structural material is the same as "seeing similarities" in figural material was tested in this study. This hypothesis was not substantiated since neither of the structural tests has a significant loading on the factor.

The other tests with significant loadings, Picture Classification and Picture-Group Naming, were expected to have significant loadings on Factor F, *verbal classification*. The items in both these tests consist of groups of pictures of objects. It was felt that seeing similarities in items of this type would be more closely related to seeing similarities in groups of words than to seeing similarities in groups of figures. This does not seem to be the case. It may be that figural properties help to determine classes of the objects in these tests.

FACTOR E. EDUCTION OF CONCEPTUAL RELATIONS (CR)

| | A | B | C |
|---|---|---|---|
| 49. Verbal Analogies I | .48 (.49 V) | .43 (.39 V) | — |
| 50. Verbal Analogies Completion | .38 (.38 V, .35 CC) | .37 (.43 V, .41 CC) | — |
| 30. Picture Classification | .37 | .24 (.40 PC) | — |
| 51. Verbal Classification | .30 (.32 VC) | .34 (.40 VC) | — |

This factor, analogous to Factor C, is in the conceptual area and is defined as the ability to see relationships in conceptual material. The first test in the list above was included under Sub-hypothesis 2*a* (seeing conceptual relations). The second test probably should have been included under that sub-hypothesis since seeing a relation should occur before a word is written to fit the relation. The other test under Sub-hypothesis 2*a*, Verbal Relations Naming, was also expected to have a significant loading on this factor. An effort was made to keep the seeing of the relations as easy as possible, however, so that the major portion of the variance would be contributed by the naming of the relations. A nonsignificant loading here indicates that this attempt was successful.

In addition to the two analogy tests there is a verbal-classification test with significant loadings in both batteries. This situation is similar to that in *eduction of perceptual relations* where there is a figural-classification test. Picture Classification also has a significant loading on the factor in one of the batteries. The fact that this test has significant loadings on both a perceptual-discovery and a conceptual-discovery factor indicates that both properties may be important in picture tests. Since Picture Classification has a significant loading in only one battery, however, this significant loading may be due to chance.

As in the case of Factor C, in spite of the fact that classification tests have significant loadings on this factor, the definition is restricted to seeing relationships since seeing similarities seems to be the unique feature of the next factor to be discussed.

FACTOR F. VERBAL CLASSIFICATION (VC)

| | A | B | C |
|---|---|---|---|
| 55. Word Classification | .45 (.42 V) | .40 (.39 V) | — |
| 51. Verbal Classification | .32 (.30 CR) | .40 (.34 CR) | — |
| 56. Word-Group Naming | — | .38 (.31 V, .36 NA) | + |

This is the *verbal-classification* factor that corresponds to the *perceptual-classification* factor. All three tests in the list above were listed under Sub-hypothesis 2*b* (seeing conceptual similarities). They all involve the classification of verbal material. Two other tests under Sub-hypothesis 2*b*, Picture Classification and Picture-Group Naming, have significant loadings on the *perceptual-classification* factor (D) rather than on this one. The final test under Hypothesis 2*b*, Similarities, was not included in either Battery A or Battery B.

A factor called *verbal classification* had been found in the evaluation analysis (Hertzka et al., 1954) where it was defined as the ability to classify verbal material. The two leading tests in the evaluation analysis were Verbal Classification and Critical Evaluation. The two leading tests in the present study are Verbal Classification and Word Classification. In spite of the fact that these tests were included in both studies, the factors in the two studies have only one test in common, therefore it is not known whether the two factors are the same or whether they represent two different factors. If the two factors are distinct, the factor found in this study has a stronger claim to the name *verbal classification*, since the tests with significant loadings here seem to fit the definition better than those with significant loadings in the evaluation study.

FACTOR G. EDUCTION OF PATTERNS (EP)

| | | A | B | C |
|---|---|---|---|---|
| 5. | Circle Reasoning | .44 | — | — |
| 24. | Letter Triangle | .38 (.33 EC) | — | — |
| 23. | Letter Series | .36 (.41 GR, .40 EC) | — | — |
| 27. | Number Series | .32 (.36 GR, .43 SM, .32 SS) | — | — |

A factor similar to this was found in the first reasoning analysis (Green et al., 1953). There it was called *eduction of conceptual patterns* and was defined as the ability to see rules, principles, or systems. All the tests loaded on the factor in this study were listed under Sub-hypotheses 3*a* and 3*b*. They all involve seeing rules or principles that are more complex than simple relations. The answers to the items in the Circle Reasoning test involve several conditions and the items in the other three tests consist of double and triple series. By contrast, the items in the trends tests under Sub-hypothesis 3*c* all involve one relation that is repeated between succeeding pairs of elements. In view of these facts, the definition of this factor was changed to the ability to see a *set* of relationships.

All the tests in the list above can be considered to be structural so that this factor might be called "eduction of structural relations." There were no figural or verbal tests in the study similar to these structural tests. Thus it is not known whether the definition of this factor should be restricted to structural tests or not. For this reason the factor is called simply *eduction of patterns* pending new empirical evidence.

FACTOR H. EDUCTION OF CORRELATES (EC)

| | | A | B | C |
|---|---|---|---|---|
| 14. | Figure Analogies Completion | .53 (.33 PR) | — | — |
| 11. | Correlate Completion II | .42 (.31 CC) | + | — |
| 23. | Letter Series | .40 (.41 GR, .36 EP) | — | — |
| 24. | Letter Triangle | .33 (.38 EP) | — | — |
| 6. | Completion of Figural Changes | .31 (.40 PR) | — | — |
| 29. | Perceptual Relations Naming | .31 (.45 PR, .30 CC) | + | — |
| 40. | Seeing Trends II | .31 | + | — |

The two leading tests here, Figure Analogies Completion and Correlate Completion II, were included under Sub-hypothesis 4*a* (finding something to fit a given perceptual relation). Three other tests were listed under this sub-hypothesis. Two of these, Completion of Figural Changes and Prescribed Relations, are very similar. Both involve finding figures to fit a given relationship. One is a completion test, however, and the other is a multiple-choice test. The completion test, Completion of Figural Changes, has a significant loading whereas the multiple-choice test, Prescribed Relations, does not. This is not too surprising since completion tests have been prominent in relation to this factor and since this factor stresses producing something to fit a given relation. The last test under Sub-hypothesis 4*a* was Figure Analogies. The seeing-relations aspect of this test seems to be most important since it has a significant loading only on *eduction of perceptual relations.*

Two of the other tests in the list, Letter Series and Letter Triangle, are structural tests listed in connection with Hypothesis 3, which has to do with the eduction of patterns. The discovery aspect probably gives them a place in the list for Factor G. In each test the examinee has to show that he knows the system by giving other letters to extend the system. Letter Series is a completion test and, although Letter Triangle is a multiple-choice test, the extension problem is still an important aspect of the test. But the presence of these two tests in the list suggests that *correlate completion* is not only a matter of supplying something to complete a relationship; it seems also to be a matter of supplying something to complete a pattern or set of relationships.

The two remaining tests in the list are Perceptual Relations Naming and Seeing Trends II. In neither test is there any need to complete either a relationship or a system. It will be noted that these two tests were also in Battery B along with Correlate Completion II without determining a correlate-completion factor. This suggests that the two tests may not belong in the list for Factor H. Reasons for this will be suggested a little later.

One of the important reasons for including the eduction-of-correlates factor in this study was to see whether it might be replaced by two factors, one perceptual and one conceptual. We seem to have an answer to this question, for neither of the tests affiliated with Sub-hypothesis 4*b* (finding something to fit a conceptual relation) had significant loadings on this factor, while three of the four tests under Sub-hypothesis 4*a* (finding something to fit a perceptual relation) had significant loadings. The two conceptual tests largely determine Factor M in this analysis.

Factor H might be called "eduction of perceptual correlates" except for the fact that both figural and structural tests are loaded on it. For this reason it is best to call it simply *eduction of correlates.* Later research may show that it should be replaced by two factors, one for figural material and one for structural.

The presence of the two unexpected tests—Seeing Trends II and Perceptual Relations Naming—can be accounted for logically by reference to the list of tests under Factor I, to be discussed next. They are both significantly related to the factor of *eduction of structural relations,* along with Correlate Completion II. The latter factor did not come out in analysis of Battery A, as might well have been the case. What probably happened is that it became confounded with Factor H in Battery A.

FACTOR I. EDUCTION OF STRUCTURAL RELATIONS (SR)

| | | A | B | C |
|---|---|---|---|---|
| 22. | Letter Grouping | — | .56 | .49 |
| 11. | Correlate Completion II | + | .50 (.44 CC) | — |
| 40. | Seeing Trends II | + | .42 | — |
| 29. | Perceptual Relations Naming | + | .39 (.34 CC) | — |
| 57. | Word Groups | — | .38 | .49 |

All the tests in this list except Perceptual Relations Naming are structural tests that were scattered among several hypotheses. Since we have already seen that Battery B yielded a factor of *eduction of perceptual relations* and a factor of *eduction of conceptual relations,* since all but one of the tests in the list for Factor I are composed of letters, and since most tests involve seeing relations, we are forced to recognize a third relations-seeing factor and to give it an appropriate name—*eduction of structural relations.* The presence of a figural test in the list may reflect the fact that there is some correlation between this factor and the parallel figural one.

All is not otherwise satisfactory with the picture of Factor I. Two tests—Letter Grouping and Word Groups—call for the seeing of similarities rather than for seeing relations in the ordinary sense. It is interesting that these two tests determine a doublet factor in analysis of Battery C, from which the remaining tests in the list for Factor I are missing. There is a possibility that the factor in Battery C is another one, an ability to see classes based upon structural material. We have already seen that a perceptual-classification factor and a verbal-classification factor are distinguished from eduction-of-relations factors in Factors D and F. It may be that there is also a structural-classification factor distinct from a corresponding *eduction of structural relations.* If this is the case, Factor I in Battery B is a confounding of two factors. Without further evidence, however, we may for the present accept the two factors listed under Factor I as being identical. A study now under way should determine whether there is also a structural-classification factor.

FACTOR J. SYMBOL MANIPULATION (SM)

| | A | B | C |
|---|---|---|---|
| 47. Symbol Manipulation II | .43 | — | — |
| 27. Number Series | .43 (.36 GR, .32 EP, .32 SS) | — | — |
| 43. Sign Changes II | .39 (.37 GR) | — | — |

Both tests that were included under Sub-hypothesis 5*a,* symbol manipulation, have significant loadings on this factor. Thus, the factor is defined as the ability to manipulate symbols. Number Series was not predicted to have a significant loading but it is quite likely that manipulation of symbols is involved in working this test. Numbers, of course, are symbols and it appears that some trial-and-error manipulation is necessary before a solution can be reached. Trial-and-error manipulation seems also to be a feature of the other two tests with significant loadings, and the trial-and-error aspect probably could be added to the definition of the factor. None of the tests that were included under Sub-hypothesis 1*b* has a significant loading on this factor.

There is a possibility that this factor is the same as the *handling-complicated-procedures* factor found in the general-reasoning study (Kettner et al., 1956) or it may be a combination of *handling complicated procedures* and *symbol manipulation.* Another possibility is that this factor is a structural one parallel to *logical evaluation.*

FACTOR K. SYMBOL SUBSTITUTION (SS)

| | A | B | C |
|---|---|---|---|
| 42. Sign Changes | .65 | — | — |
| 18. Form Reasoning | .53 | — | — |
| 27. Number Series | .32 (.36 GR, .32 EP, .43 SM) | — | — |

Sign Changes and Form Reasoning were the two tests included under Sub-hypothesis 5*b, symbol substitution,* so this factor can be defined as the ability to substitute symbols quickly. This factor differs from the preceding one in that no trial-and-error manipulation seems to be necessary. All that is required is the ability to substitute symbols according to simple, given rules.

As in the previous factor, Number Series has a significant loading on this factor but here the finding is not so reasonable. One possible explanation is that this factor is a combination of *symbol substitution* and *numerical facility.* Both Sign Changes and Number Series involve numbers and Form Reasoning generally has had a near-significant loading on numerical facility in previous studies. The high loading of Form Reasoning argues against the possibility that this is entirely a number factor.

FACTOR L. NAMING ABSTRACTIONS (NA)

| | A | B | C |
|---|---|---|---|
| 31. Picture-Group Naming | — | .38 (.33 PC) | .37 |
| 56. Word-Group Naming | — | .36 (.31 V, .38 VC) | .46 (.37 V) |
| 39. Seeing Trends | + | .34 | — |
| 53. Verbal Relations Naming | + | .32 (.33 CC) | — |
| 28. Object Synthesis | — | — | .40 (.40 SX) |

This appears to be one of the hypothesized verbalizing factors. The first four tests in the list above were included under the general Hypothesis 6 (verbalizing ability). They call for the naming of classes, relations, or trends. The last test in the list above, Object Synthesis, calls for naming objects that fit certain requirements. On the basis of these considerations the factor has been called *naming abstractions.*

This factor is similar to one found by Adkins and Lyerly (1951), which they called *concept formation*. The first two tests in the list above led their list for the *concept-formation* factor. The factor here seems to be more restricted than the one found by Adkins and Lyerly. All tests on *naming abstractions* are verbal tests except Picture-Group Naming while the tests on *concept formation* included perceptual and structural tests as well as verbal tests. In addition, all tests that have significant loadings here are completion-type tests that require verbal answers. In the Adkins' study, both completion and multiple-choice tests had significant loadings on *concept formation*. Perhaps a portion of their *concept formation* has been segregated in this study.

A naming factor was also found by Carroll (1941). The leading tests on that factor involved speed of naming colors and speed of naming forms. It does not seem that *naming abstractions* is sufficiently similar to Carroll's naming factor to be identified with it.

FACTOR M. EDUCTION OF CONCEPTUAL CORRELATES (CC)

| | | A | B | C |
|---|---|---|---|---|
| 53. | Verbal Relations Naming | .54 | .33 (.32 NA) | — |
| 21. | Inventive Verbal Relations | .51 (.41 V) | .47 (.53 V) | — |
| 50. | Verbal Analogies Completion | .35 (.38 V, .38 CR) | .41 (.43 V, .37 CR) | — |
| 11. | Correlate Completion II | .31 (.42 EC) | .44 (.50 SR) | — |
| 29. | Perceptual Relations Naming | .30 (.45 PR, .31 EC) | .34 (.39 SR) | — |
| 54. | Vocabulary Completion | — | .44 (.40 V, .41 AF) | + |

The tests with significant loadings on this factor are scattered among various sub-hypotheses. Since both tests listed under Sub-hypothesis 4*b* (finding something to fit a given conceptual relation) have significant loadings on this factor, it might well be called *eduction of conceptual correlates*. The other tests, however, do not seem to fit this interpretation so well. They are completion-type tests, but the main task in two of them is that of naming an observed relationship. One of these tests is a figural test and one other test is a structural test.

One rationalization would be to extend the conception of the *eduction of conceptual correlates* to the act of producing words that stand for abstract ideas, the ideas being given or readily discovered. This conception brings us close to the definition of another factor—*expressional fluency*—which had been defined as the ability to put ideas into words, at the time this study was conducted. More recent information, however, fairly well indicates that *expressional fluency* is an ability to produce connected discourse; to form sentences with appropriate sentence structure. The tests in the list for Factor M call for single words as responses, or simple phrases, at the most, which fairly well eliminates the hypothesis that this is the factor of *expressional fluency*. It seems, then, that we have found a conceptual factor for the production of correlates, parallel to the previously known perceptual factor of the same kind. The presence of the naming tests may require a somewhat broader conception of the factor or it may mean some confounding with an unidentified factor.

FACTOR N. SENSITIVITY TO PROBLEMS (SP)

| | | A | B | C |
|---|---|---|---|---|
| 38. | Seeing Problems | — | — | .50 (.40 Pe) |
| 1. | Apparatus Test | — | — | .45 (.51 Pe) |
| 37. | Seeing Deficiencies | — | — | .39 (.40 Re) |
| 45. | Social Institutions | — | — | .38 (.50 Pe) |

This factor is called *sensitivity to problems,* which has been defined as the ability to see defects, needs, and deficiencies. All tests that were hypothesized to measure *sensitivity to problems* have significant loadings on the factor here, and no other tests have significant loadings. These tests all involve the seeing of problems of some kind. Seeing Problems involves problems connected with common objects; Apparatus Test involves problems with mechanical devices; Social Institutions involve problems with social institutions; and Seeing Deficiencies involves problems with plans or activities.

In the creativity study (Wilson et al., 1954), only two of these tests, Apparatus Test and Social Institutions, were present and had significant loadings on *sensitivity to problems.* Thus the factor seemed to be rather restricted. It was included in this study in order to test its degree of generality by adding somewhat different tests. From the variety of tests in the list above it appears that the factor is more general than had been indicated in the previous study.

FACTOR O. PENETRATION (Pe)

| | A | B | C |
|---|---|---|---|
| 1. Apparatus Test | — | — | .51 (.45 SP) |
| 45. Social Institutions | — | — | .50 (.38 SP) |
| 44. Similarities | — | — | .48 |
| 48. Unusual Uses | — | — | .48 (.35 O, .31 SX) |
| 38. Seeing Problems | — | — | .40 (.50 SP) |

Since this factor has three tests in common with the preceding one, there is some difficulty in distinguishing between the two. A clue is given, however, by the two tests, Unusual Uses and Similarities, which have significant loadings on this factor but not on the previous one. Neither is strictly a seeing-problems test. The Unusual Uses test calls for listing unusual uses for a common object, and the Similarities test calls for naming similarities between common objects.

In the creativity study, Social Institutions and Apparatus Test had additional significant loadings on a doublet which was not interpreted although it was suggested that it might be a trace of a "penetration factor," which had been hypothesized. In that study, penetration was hypothesized as an ability to see beyond the immediate and the obvious.

Three tests—Apparatus Test, Seeing Problems, and Social Institutions—in the list above have significant loadings on Factor N *(seeing problems).* If it can be assumed for these three tests that the variance for seeing immediate or obvious problems is accounted for by Factor N, then Factor O might well represent the variance due to seeing problems that are not so immediate or obvious. It is to be expected that those individuals who can see beyond the immediate and obvious in the Similarities test, should be able to produce more similarities, and should be able to see far-fetched uses of objects in the Unusual Uses test.

The definition of this factor comes fairly close to Sub-hypothesis 9*a* (producing remote responses). It is quite possible that this factor corresponds to that sub-hypothesis (see discussion under Factor Q). If this is so, one question of interest here is why the tests under Sub-hypothesis 9*a* do not have significant loadings on this factor. One of these tests is Consequences (remote score). Perhaps one reason this test does not have a significant loading on Factor O is that it deals with things that are remote in time whereas the tests loaded on Factor O do not. The other three tests under Sub-hypothesis 9*a* were objectively scored tests whose items involved remote meanings of words. These tests are of a different type than those loaded on Factor O.

### Factor P. Associational Fluency (AF)

| | | A | B | C |
|---|---|---|---|---|
| 10. | Controlled Associations II | — | .48 | .61 |
| 2. | Associations III | — | .46 (.31 V) | .36 (.42 V, .35 Re) |
| 54. | Vocabulary Completion | — | .41 (.40 V, .44 CC) | .33 (.44 V) |
| 3. | Associations IV | — | .40 | .47 |
| 9. | Controlled Association | — | — | .56 (.30 O) |

All tests with significant loadings on this factor were listed under the two sub-hypotheses under *associational fluency.* They all require the production of words, but they vary in several different ways. The stimuli are of three different kinds—one given word, two given words, or a definition. The words to be produced have five different restrictions—words synonymous with one given word, words synonymous with two given words, words fitting given definitions, words associated with one given word, and words associated with two given words. The number of correct responses that are possible for each item varies from one to many. The number of responses that are asked for in each item varies from one to twelve. Some of the tests are speed tests and the others are relatively more in the nature of power tests. None of these differences seem to make an appreciable difference. The main feature of all these tests is the production of words. For this reason, the definition of this factor is given as the ability to produce words from a restricted area of meaning.

A more recent study in the Aptitudes Project (Guilford, Kettner, & Christensen, 1955) included all tests in the list above except Controlled Associations II. In that study these tests produced two factors, with Associations IV and Controlled Association leading one factor and with Associations III and Vocabulary Completion leading the other factor. The first factor was called *associational fluency* and the second one was not identified pending the outcome of the present analysis. It can now be suggested that the second one might have been *eduction of conceptual correlates,* the Vocabulary Completion test being in common with Factor M in this study.

### Factor Q. Originality (O)

| | | A | B | C |
|---|---|---|---|---|
| 4. | Cartoons | — | — | .47 |
| 32 | Plot Titles (cleverness) | — | — | .43 |
| 48. | Unusual Uses | — | — | .35 (.48 Pe, .31 SX) |
| 8. | Consequences (remote) | — | — | .32 (.34 IF, .41 SX) |
| 9. | Controlled Association | — | — | .30 (.56 AF) |

This is the *originality* factor that was found previously in the creativity study where it was defined as the ability to produce remote, uncommon, or clever responses. These were the three sub-hypotheses for the *originality* factor. It was expected that this factor might be replaced by two or three factors if given the chance. Such apparently is not the case. The tests in the list above represent all three sub-hypotheses. Thus it seems that all three properties should be included in the definition of the factor.

Controlled Association has a significant loading on the factor but was not included on any of the sub-hypotheses for *originality.* It did have a barely significant loading on *originality,* however, in the creativity study, so it is not completely surprising that it has a significant loading here. The Quick Response test which was included under Sub-hypothesis 9*b* had a significant loading on *originality* in the creativity study but not here. Perhaps this is due to the fact that the "uncommonness" key used here was not derived from the sample that was tested.

Three objectively scored tests were also included among the tests for *originality*—Associations III, Associations IV, and Remote Verbal Similarities. None of these tests had significant loadings on the factor.

The two tests under Sub-hypothesis 9*c* (producing clever responses) have the highest loadings on this factor. It is possible that this factor should be defined as the ability to produce clever responses even though tests from the other sub-hypotheses have significant loadings here. It is possible to produce clever responses for the other tests that have significant loadings on the factor. If only the clever responses had been scored in these tests, they might have had higher loadings than they did. At any rate, it is quite possible that those individuals who produce clever responses to these tests produce a larger number of responses. This would explain why tests besides Plot Titles (cleverness) and Cartoons had significant loadings on the factor even though they do not obviously fit the sub-hypothesis "producing clever responses," and permit the defining of originality as "cleverness."

Factor R. Redefinition (Re) and Judgment (J)

| | A | B | C |
|---|---|---|---|
| 19. Gestalt Transformation | — | — | .48 |
| 25. Logical Classification | — | — | .44 (.39 V) |
| 37. Seeing Deficiencies | — | — | .40 (.39 SP) |
| 2. Associations III | — | — | .35 (.42 V, .36 AF) |
| 36. Remote Verbal Similarities | — | + | .34 |

The two leading tests on this factor were among the tests hypothesized to contain *redefinition* variance. Both of these tests have had significant loadings on *redefinition* in previous studies. Two other tests, Remote Verbal Similarities and Seeing Deficiencies, have had significant loadings on the *judgment* factor in previous studies. As stated under the discussion of the hypotheses for *redefinition,* tests of both these factors have come out together on a single factor in several analyses. Since the two factors have not appeared separately in the same analysis, it is not known whether the two factors are distinct. No new light is thrown on the situation here except that a factor similar to the previous ones has reappeared.

*Redefinition* has been defined as the ability to redefine the uses of objects and the contents of statements. This definition does not fit Tests 36 and 37 very well. *Judgment* was defined in the second reasoning study as the ability to make wise choices in a somewhat ambiguous situation where it is necessary, in general, to make assumptions over and above the facts that are given. This definition fits all the tests in the list above except Associations III. From all the evidence, it appears that this is a confounding of two factors that were probably confounded once before.

Factor S. Ideational Fluency (IF)

| | A | B | C |
|---|---|---|---|
| 33. Plot Titles (low quality) | — | — | .60 |
| 7. Consequences (low quality) | — | — | .58 |
| 8. Consequences (remote) | | — | .34 (.32 O, .41 SX) |

The two leading tests on this factor were included in this study as reference tests for *ideational fluency.* This factor was defined in the creative-thinking study as the speed of calling up ideas in a situation in which there is relatively little restriction and quality does not matter. Both of the scores for the Consequences test have significant loadings. Evidently the low-quality responses were not completely separated from the remote responses in the scoring, as is indicated by the fact that the two scores have an intercorrelation of .39.

FACTOR T. SPONTANEOUS FLEXIBILITY (SX)

| | A | B | C |
|---|---|---|---|
| 8. Consequences (remote) | — | — | .41 (.32 O, .34 IF) |
| 28. Object Synthesis | — | — | .40 (.40 NA) |
| 48. Unusual Uses | — | — | .31 (.48 Pc, .35 O) |

In the creativity study, *spontaneous flexibility* was defined as the ability to produce a diversity of ideas. In that study both Consequences (remote) and Unusual Uses had significant loadings. The other test on this factor, Object Synthesis, does not fit the definition very well since only one answer is required for each item. It may very well be, however, that having a diversity of ideas is helpful in arriving at an answer to the items in this test. At any rate, because of the similarity between this factor and the one found in the creativity study, it is called *spontaneous flexibility*.

FACTOR U. UNIDENTIFIED (U)

| | A | B | C |
|---|---|---|---|
| 39. Seeing Trends | .59 | + | — |
| 34. Prescribed Relations | .41 | — | — |

No attempt is made to interpret this doublet since the common element of these two tests is not obvious.

The remaining factors in the three batteries are residuals. None has a loading greater than .30 in absolute value.

## DISCUSSION

### *Relations of the Factors to Those in Previous Studies*

This study had several aims. One of these was the verification of factors found in previous studies. Eleven factors were under investigation. Five of these had been found in two or more studies in the Aptitudes Project. Four of the five appeared in this study in substantially the same form as before. These factors are: *eduction of perceptual relations, eduction of conceptual relations, eduction of correlates,* and *redefinition* (confounded with *judgment*).

Five of the six factors that had been found in only one study previously were verified. These factors are: *eduction of patterns, associational fluency, originality, sensitivity to problems,* and *verbal classification.*

*Facility with verbal relations* did not reappear. In the evaluation analysis, in which it had been previously found, the relatively large and somewhat heterogeneous list of tests related to it made interpretation difficult. Five of the tests related to it in the evaluation study and also present in this study proved to have significant loadings on *verbal comprehension, verbal classification,* and *associational fluency.* The first two of these appeared in the evaluation study. The inference is that the factor called "facility with verbal relations" was a composite of *associational fluency* plus other unidentified factors.

Tests for three reference factors—*verbal comprehension, general reasoning,* and *ideational fluency*—were included as marker tests. These three factors emerged as expected. In addition, the previously known factor of *spontaneous flexibility* emerged even though no marker tests were included for it.

Five new factors were discovered and named: *perceptual classification, eduction of structural relations, naming abstractions, eduction of conceptual correlates,* and *penetration.* There was some indication of another new factor that could be called "structural classification," but it was not clearly to be distinguished from the new correlates factor. Perhaps it is incorrect to say that the factor of *penetration* is new. Such a factor had been somewhat anticipated in the creativity study and a doublet factor could have been so identified.

### *Relation of the Factors to the Hypotheses*

The discussion of this subject will follow fairly closely the order of discussion of the hypotheses given in the early part of this paper. First, some more general questions were asked pertaining to a few of the factors, then some specific hypotheses were stated pertaining to each factor under investigation.

The question of degree of generality was raised concerning two of the creative-thinking factors—*sensitivity to problems* and *originality.* In this study, *sensitivity to problems* appears to be somewhat more general than in the creativity study. It pertains to seeing defects or deficiencies in things other than mechanical gadgets and social institutions; more specifically, this extends to familiar, nonmechanical objects and to planned operations.

As to *originality,* on the surface it seems that the factor is as broadly general as it was before, pertaining to the production of unusual, remotely connected, or clever responses. The discovery of a *penetration* factor, however, suggests that remote associations may be dependent upon a factor other than *originality* or that there are different kinds of remoteness involved in tests of these two factors.

Questions were raised concerning the possible identification of two pairs of factors. The first pair included *associational fluency* and *facility with verbal relations.* It was found that the latter factor did not emerge, as such, in this study and that when previously found it probably represented a confounding of *associational fluency* with other unknown factors. The second pair was composed of *redefinition* and *judgment.* Tests for the two came out loaded on the same factor, but owing to the lack of traditionally definitive tests for *judgment,* the issue is still uncertain.

The general question was raised as to whether tests that call for classifying activity or the recognition of similarities among objects would go into the same categories as the tests that call for recognition of relations between objects. From the results of this study we have strong evidence that there is a group of factors representing abilities to classify objects separate from the group previously known representing abilities to cognize relations. There appear to be as many as three in each group, having to do with figural, structural, and verbal material, respectively.[8]

The introduction of a number of naming tests into the study raised the question of whether there would be one new factor representing the ability to produce names or verbal descriptions for ideas or perhaps several new verbalizing factors, or none. The results seem to be strongly on the side of the hypothesis of one such naming or verbalizing ability. It does not seem to matter whether the thing to be verbalized is a class or a relation or a system, so long as it is an abstraction of some kind.

The fate of the specific hypotheses concerning many of the factors may be treated very briefly:

*Eduction of perceptual relations.* The main hypothesis tested was whether seeing relationships and seeing classes among figural objects call for one primary ability or two. The results indicate two separate abilities, the other being called *perceptual classification.*

*Eduction of conceptual relations.* The hypotheses and findings parallel those for the preceding factor. There is a factor of *verbal classification,* found for the second time. Although there was no prediction of it at the time this study was initiated, there emerged a factor that could be identified as "structural classification," but since it was a doublet and bore apparent similarity to another structural factor, it was not accepted as a demonstrated factor.

*Eduction of conceptual patterns.* Tests were included to determine whether this ability extended to discovering rules and principles, also trends, as well as patterns. The answer seems to be that it pertains to all but seeing trends. Tests of the latter type go with tests of seeing relations. A trend may be regarded as a linear pattern or a succession of examples of the same relationship end to end, and hence lacks the complexity that is characteristic of tests of this factor. The results indicate another kind of conclusion, and that is the probable restriction of this ability to perceptual and structural tests. The qualifying term "conceptual" has therefore been dropped from the name of the factor. On the basis of other distinctions being found between tests of figural and structural materials, we may naturally ask the question whether there should not be two factors in place of the one obtained, and perhaps a third pertaining to conceptual materials.[9]

*Eduction of correlates.* The main hypothesis tested was whether there would be two factors—perceptual and conceptual—to replace the one that had been previously found. The results strongly favor the distinction between two, the one being conceptual, but the other being heavily featured by structural (letter) material. This raises the question of the existence of a third factor of eduction of correlates among figures.

*Symbol manipulation.* The answer pertaining to this factor is that there are two distinct primary abilities, the other being designated as *symbol substitution.*

*Verbalizing ability.* The result concerning this hypothesis turned out to be one new factor of abstraction naming, which pertains to various kinds of abstractions, as indicated in the general discussion.

*Sensitivity to problems.* This factor seems to be a little broader than when first discovered, as explained in the general discussion.

*Associational fluency.* The new, positive information concerning this factor indicates that it can be tested by calling for few or many responses to stimulus words. The finding of a new factor of *eduction of conceptual correlates,* however, which also involves the giving of a meaningful response that satisfies a given relationship, calls for some kind of discrimination between the two. The best basis at present is that the latter factor involves one best or most conventional response whereas *associational fluency* involves a variety of responses. This kind of discrimination contributed to the distinction between "convergent" and "divergent" productive thinking, which played an important role in the development of the "structure of intellect" (Guilford: 1956, 1957).

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[8] It was the results such as these in the present investigation that gave the strongest impetus to attempts to organize the intellectual factors in a system that has been called the "structure of intellect" (Guilford: 1956, 1957, 1958).

[9] Subsequent to this study, it has been proposed that the well-known factor of *spatial orientation* is the parallel, figural *eduction of patterns,* and that *general reasoning* is the parallel, conceptual *eduction of patterns* (Guilford: 1956, 1957).

*Originality.* Although, as indicated above, *originality* still seemed to be involved in tests calling for uncommon, remotely associated, and clever responses, there is some indication that remote associations may be also an indicator of the new factor of *penetration.*

*Redefinition.* The separability of this factor from that of *judgment* is still an open question.

*Facility with verbal relations.* The indications are that this factor, which appeared only once before, was then a composite. It did not reappear, as such.

*Verbal classification.* The ability to recognize classes of things presented verbally was confirmed, with the factor supporting the hypothesis of "seeing conceptual similarities."

## *Categories of Factors*

Earlier work in the project, and this particular study, recognized the general domains or categories of reasoning, creativity, planning, and evaluation. While these categories have had heuristic value, it has become rather clear from the results of the present investigation that some new categories are in order. The category of evaluation is the only one that seems to have persistent value.

There has been increasing recognition that certain factors represent abilities to discover information, or to rediscover or recognize it, in the form of things, relations between things, classes, patterns or systems, and so on. Other factors have been distinguished from discovery factors by the fact that they involve production of new information from given information. They can be called production factors. Within this group a further distinction has developed, as suggested above: that between convergent thinking and divergent thinking. The former is aimed toward a conventional response of some kind while the latter seeks a variety of responses.

It is possible to give the former, heuristic categories more empirical meaning by reference to these new factor-category concepts. Reasoning may be defined as relational thinking. We cognize relations, we use relations in producing new information, and we evaluate the products of these steps in terms of logical consistency. Creative thinking seems to depend most directly upon the divergent-thinking category of abilities. In a broader sense, creative production, as in ordinary problem solving, also clearly involves other than divergent-thinking operations.

## *Improvement of Tests*

The third objective of this study was more incidental than the others. Only general implications will be given here concerning the kinds of improvements that are indicated for tests as a consequence of new information. In addition to knowledge of the statistical data concerning each test we also learn something concerning its factorial validity; what common factors it measures in the population involved and to what extent. We thus learn which tests are best for each factor and what secondary factor variances to attempt to eliminate in future forms of those tests. We learn more about the properties of some of the factors so that perhaps new and better types of tests can be constructed. The results of this investigation carried its expected share of such implications.

## SUMMARY

The main purpose of this study was to investigate in the same analysis certain factors that had been found previously in the domains of reasoning, creativity, and evaluation. Three major objectives were: (*a*) verification of factors found only once or twice before, (*b*) clarification as to their scope and properties, and (*c*) derivation of information that would lead to improvement of tests measuring these factors.

Eleven factors were selected for investigation, excluding those of doubtful nature and those needing more intensive study than could be given them in such a general survey study as this one. General questions asked pertained to the possible identity of factors found in different studies, to the generality or scope of certain factors, and to the possibility that some formerly apparently unitary factors might be replaced each by two. The introduction of a number of tests calling for the examinee to name or describe relations, classes, or patterns called for hypotheses regarding the possible finding of one or more new verbalizing factors. For most expected factors alternative hypotheses were stated as to their properties.

Fifty-seven tests were selected, adapted, or constructed to test the hypotheses, with some of them being introduced as marker tests of reference factors (other than the 11 being investigated). The twelve-hour battery had to be broken up into three partially overlapping batteries. Each battery was administered to a sample of approximately 200 air cadets, two in the Air Force and one in the Navy. Three factor analyses were done by the centroid method followed by orthogonal rotations of axes.

Twenty psychological factors were interpreted, five of which were reference factors. Nine of the 11 factors under investigation were found in somewhat the same form as before, with some clarification as to their unique properties. They are: *eduction of perceptual relations, eduction of conceptual relations, verbal classification, eduction of patterns, eduction of correlates, sensitivity to problems, associational fluency, originality,* and *redefinition* (probably confounded with *judgment*). *Facility with verbal relations* did not reappear, as such, hence it was probably previously a composite factor. *Symbol manipulation* appeared but some of the symbolic tests determined another factor, distinct from it—*symbol substitution.*

Five new factors were found: *perceptual classification* (ability to recognize classes of figural objects), *eduction of structural relations* (ability to see relations between structural objects, such as groups of letters), *naming abstractions* (ability to name or describe abstractions such as classes, relations, and patterns), *eduction of conceptual correlates* (ability to supply a response when needed to complete a meaningful whole), and *penetration* (ability to see remote connections or similarities). A doublet factor might have been interpreted as "structural classification" (an ability to recognize classes of structural objects), but it could not be clearly distinguished from *eduction of structural relations.*[10]

A consideration of natural groupings of factors suggests that the heuristic categories of reasoning and creative thinking would be more appropriately replaced by categories of discovery, or cognition, and of productive thinking. The latter could be subdivided into a convergent-thinking and a divergent-thinking group. The category of evaluation seems to remain useful.

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[10] In current writings the term "structural" has been replaced by "symbolic" and the term "conceptual" by "semantic" in order to reduce ambiguities.

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